been made to look for any kind of motion except such as would be caused by something akin to viscosity.

Incidentally the author points out that by rotating the whole optical apparatus and observer, instead of the disks, at a very moderate speed, a shift of the bands should be seen; and even that the earth's rotation would with a large enough frame produce an effect, which latter, however, it appears difficult or impossible to observe, not on account of its smallness, but on account of its constancy.

The effect to be expected on Fresnel-Fizeau principles from whirling *air*, was unfortunately just too small for the author to safely observe. The residual disturbing causes just masked it, but it is probably not beyond the reach of another attempt with a still more thoroughly steady machine, if anyone feels inclined to persevere so far. At the same time if it be supposed that any microscopic trace of true ether effect still possibly exists (which the author wholly disbelieves), and if a further attempt be hereafter made to observe it, a number of slight residual disturbing causes would be got rid of (and probably other difficulties introduced) by rotating the machine in a vacuum.

"Second Report on a Series of Specimens of the Deposits of the Nile Delta, obtained by Boring Operations undertaken by the Royal Society." By John W. Judd, C.B., LL.D., F.R.S., Professor of Geology in the Royal College of Science. Communicated by desire of the Delta Committee. Received February 11,—Read March 4, 1897.

The last report on the borings undertaken in the delta of the Nile under the auspices of the Royal Society was communicated to the Society by the direction of the Delta Committee on November 12, 1885, and published in No. 240 of the 'Proceedings.' This report dealt with the materials obtained from the three borings made at Kasr-el-Nil, at Kafr-ez-Zayat, and at Tantah, which reached depths of 45 feet, 84 feet, and 73 feet respectively. Although these borings made known to us the character of the delta deposits at greater depths than the explorations made by Mr. Leonard Horner and M. Linant de Bellefondes, yet none of them succeeded in reaching the solid rock on which these deposits lie, and in which the Nile Valley was originally excavated. It was therefore decided by the Delta Committee to make still more strenuous efforts to attain this result—a result which the sections published by Figari Bey, said to be based on borings made for the purpose, led the Committee to believe might be arrived at with a moderate expenditure.

In their attempts to carry out this important work, the Delta Com-

mittee have received the most valuable aid from the Secretary of State for War, the Inspector-General of Fortifications, and the officers of the detachment of the Royal Engineers attached to the Army of Occupation in Egypt; and their thanks are especially due to Colonel Turner, R.E., Captain Dickenson, R.E., Lieutenant Godly, R.E., and Corporal Bellinger, R.E. To the Egyptian Railway Administration the Committee is indebted for permission to choose a site for boring on their land, and for much assistance given from time to time.

Zagazig having been chosen by the Royal Society Committee as a suitable site for the next attempt to penetrate the delta deposits, a Legrand-and-Sutcliffe boring apparatus, which had already been set up and tested at Kasr-el-Nil, was brought to the selected locality, and arrangements were made for carrying the boring to the depth of 100 feet with a 5-inch lining tube, and to another 100 feet with a 4-inch tube. It was considered certain at that time—and many published statements supported the belief—that the solid rock of the Nile Valley could not fail to be met with at a depth of *less than* 200 feet. The spot where the boring commenced had an elevation of 26 feet 1 inch above the sea-level at Alexandria, as determined by the Egyptian Public Works Department.

A pit having been dug to the depth of 8 feet, and a platform erected over it, the 5-inch pipes were driven in and carried without any great difficulty to a depth of 97 feet from the surface. At this depth a 4-inch pipe was driven within the other, and the boring operations were proceeded with. When, however, a depth of 190 feet 6 inches had been reached, it was found impossible to drive the pipe farther, its bottom being still in a quicksand. Thus the work, which had been commenced on May 7, 1886, had to be discontinued on August 14 of the same year.

On the recommendation of Captain Dickenson, R.E., who had so ably and successfully directed these operations, it was decided by the Delta Committee to resume the work at this borehole in the following year, with a 3-inch pipe. The necessary apparatus having been sent out, the work was resumed on April 21, 1887, and by vigorous and skilful efforts carried to a depth of 339 feet 6 inches.

At that point, however, it was found impossible to drive the 3-inch pipe farther, but a rod was pushed down 5 feet 6 inches without reaching solid rock: the exploration thus attained a total depth from the surface of 345 feet, or 319 feet below the sea-level.

From the surface to a depth of 115 feet the strata passed through in the Zagazig boring closely resembled those already reported upon as occurring in the three earlier borings of Kasr-el-Nil, Kafr-ez-Zayat and Tantah, and consisted of alternations of desert-sand and Nile-mud. All the samples sent home have been carefully

examined, and the minerals in them are found to be identical in character with those in the deposits already described. Some small pieces of pottery and bone were found at depths varying from 8 to 27 feet from the surface.

In the alluvial mud, which prevails from the surface to the depth of 20 feet, small tubular and knot-like bodies abound. These are undoubtedly formed by the deposition of calcium carbonate on the rootlets of plants, giving rise to beautiful calcareous tubes, and to knot-like bodies where the rootlets branch. These calcareous tubes and knot-like bodies are covered on the outside by cemented mud-grains, and present a singular resemblance to some of the arenaceous foraminifera like *Astrorhiza*. The knot-like bodies are evidently formed where the rootlets have branched or become twisted, and certain of them simulate in outward form some of the bodies referred to as *Stacheiæ*. As we go downwards in the deposit, these bodies become fewer in number and less definite in form; and in the clay from depths between 75 and 92 feet, we find no such tubular bodies, but instead of them masses of concretionary limestone or "race," probably resulting from the solution and re-deposition of the calcium carbonate. The sand, which prevails from depths of 20 to 75 feet, varies in coarseness, and is almost always well rounded and evidently wind-borne, and is in places indurated into a sand-rock or imperfect sandstone.

From 75 feet to 92 feet an indurated alluvial mud was found. The tube-like bodies are here wanting, but in their place we find the irregular masses of concretionary argillaceous limestone or "race," evidently formed, as we have seen, by the solution and re-deposition of the calcium carbonate originally deposited on the root-fibres. The most careful washing of these clays by my assistant, Mr. F. Chapman, failed to reveal any trace of contemporary organisms, but at a depth of 90 feet he obtained a good specimen of a Nummulite (*N. Guettardi*, d'Arch. and Haime) evidently derived from the Eocene limestones of the country.

At the depth of 115 feet a very noteworthy change was found to occur in the characters of the beds passed through, a mass of coarse sand and shingle being met with, and this continued to the depth of 151 feet. At the latter depth a band of yellow clay 2 feet thick was passed through, and under it sand and shingle beds prevailed till the lowest depth reached, 345 feet. Specially coarse shingle beds were found at depths of 121 feet, 160 feet, 175 feet, 190 feet, 208 feet, 250 feet, 265 feet, and 270 feet. In some of these shingle beds the fragments, which were usually well rounded—often, indeed, perfect pebbles—were very coarse, the fragments being of all sizes up to that of a hen's egg.

It is interesting to note that a boring made at Rosetta in the

summer of 1885 by Mr. T. E. Cornish, C.M.G., Director of the Alexandria Waterworks, gave a section very similar to that at Zagazig. The object of this boring was to obtain a supply of fresh water for the town of Rosetta, but success not having been attained when a depth of 153 feet 4 inches from the surface had been reached, it was found too costly to carry the work farther.

For details of this interesting boring the Royal Society's Committee is indebted to Sir Colin Scott Moncrieff, R.E., K.C.M.G., at that time Under-Secretary of State for the Public Works Department of the Egyptian Government. The boring was carried down by a 5-inch tube, the surface being 9 feet 4 inches above mean sea level. Various beds of sand and mud, the latter containing in some places impure lignite, were found down to the depth of 143 feet 8 inches from the surface, but at this latter depth a mass of "coarse sand and pebbles" was found, which was followed down for about 10 feet. No specimens from the boring have reached this country.

It will thus be seen that in the case of the Zagazig boring we find at the depth of 115 feet 8 inches (89 feet below sea level) a sudden change from the blown sand and alluvial mud of the Nile delta to masses of shingle and sand, and that the same change is found to take place at the Rosetta boring at a depth of 143 feet 8 inches (134 feet 4 inches below sea level). That these shingle beds were deposited under totally different conditions to those which prevailed while the delta deposits were laid down, and that they were in fact the product of ordinary fluviatile action, can scarcely be doubted, and the determination of the geological age of the great gravelly deposit which is now shown to underlie the modern delta deposits, and to attain depths which certainly in places exceed 230 feet, becomes a problem of the greatest importance and interest.

That the surface of these old gravelly deposits is a very uneven one is indicated by the difference of depth at which it is found at Rosetta and Zagazig respectively. It is possible, indeed, that this gravelly floor may in places rise through the whole of the Nile deposits, and form the present surface of the country. The late Sir Samuel Baker, in a letter addressed to the Royal Society's Delta Committee on February 20, 1886, called attention to the existence of the so-called "turtle-backs," which he regards as interesting proofs of "the pre-existence of desert, before the Nile deposit had converted the lower level into delta."

"There are," he says, "several of these turtle-backs, varying from two to twenty acres, which represent the original desert that has, from its superior level, never been subjected to the inundation of the river. These patches of sand appear like islands in the wide expanse of dark alluvium, which exhibits the maximum deposits of the Nile." Several of these turtle-backs may be seen from the rail-

way between Tantah and Cairo. A sketch section, given by Sir Samuel Baker, shows that in his view they form part of the original floor on which the Delta deposits were laid down.

In considering this suggestion of Sir Samuel Baker, however, it should be borne in mind that the alluvial mud of the Nile alternates with considerable masses of blown sand, and that the turtle-backs may be the surfaces of great lenticular patches of such blown sand. Communications which have been made to me by Colonel J. C. Ross, R.E., C.M.G., formerly Inspector-General of Irrigation, seem to point to the same conclusions as those arrived at by the late Sir Samuel Baker. Colonel Ross states that the turtle-backs sometimes show a distinctly shingly character like that of the materials derived from the borings.

Bearing in mind the extreme importance of determining the geological age of the deposits underlying the delta-deposits, I have made the greatest efforts to obtain contemporary fossils from their materials. The clays have been most carefully washed and picked over, and the sands sifted and searched; but although derived fossils are in some cases very abundant, not a single organism has been found which lived when the beds were deposited, and would serve to throw light on the geological period to which they must be assigned. Even the fine clays between 151 and 153 feet, which, it was hoped, might have permitted of the preservation of some organic forms, have proved to be hopelessly barren of fossil remains.

As it was of considerable interest to determine the source of the various pebbles making up the shingle deposit, which we may conveniently speak of as the "Sub-delta formation," I placed myself in communication with Dr. Karl von Zittel, F.M.G.S., of Munich, who possesses such a unique knowledge of the rocks and fossils of North Eastern Africa. In his obliging communication, he has indicated the probable source of the pebbles which I forwarded to him, and writes as follows :—

"The quartz and chalcedony pebbles from depths of 120, 160, 245, and 270 feet are almost absolutely pure examples of those rocks. The sandstones (for example, those from the depth of 120 feet) rather recall, in their general appearance, the Tertiary Sandstone of Gebel Achmar, near Cairo, than the older (Cretaceous) Nubian Sandstone of Upper Egypt. The quartz and chalcedony pebbles, before referred to, might also be derived from the Gebel Achmar Sandstone. The absence of limestone pebbles is striking; it would appear that only the harder rocks have been preserved in the gravels of the Delta, the softer ones having been possibly worn away."

With respect to the igneous rocks found as pebbles in these shingle beds, Dr. von Zittel suggests, from their macroscopic appearance, that they may be derived "from the side valleys of the Arabian Desert."

The microscopic examinations of these pebbles of igneous rocks shows that they consist of much altered hornblende andesite, or porphyrite (208 feet), and andesitic (porphyritic) tuffs (121 feet, 175 feet, 208 feet). These rocks remind one of those of Djebal Dockran, except from the circumstance that they are not coloured by the manganese epidote like the celebrated "Porfido rosso antico." Altered quartz-andesite, dacite, or quartz-porphyrite (160 feet) with rhyolite, showing beautiful flow-structure and many foreign fragments caught up in its mass (160 feet),—and rhyolite or quartz-andesite tuffs (170 feet, 250 feet) were also found.

Of metamorphic rocks, quartzites, which are evidently altered sandstones, were found somewhat frequently. And in some cases (208 feet, 250 feet) the pebbles showed evidence that the rocks from which they were derived had undergone great crushing—the mylonitic (cataclastic) structure and the brecciated and veined structures affording striking evidence of the deformation to which the rocks had been subjected.

Many pebbles of sandstone, sometimes showing stratification and fault-structures, but destitute of organic remains, were obtained at various depths. Some examples of sand-grains bound together with iron oxide (like our "carstone") also occur among the pebbles. The chief fossiliferous rocks found were as follows:—

Pebbles of flinty limestone from depths of 160, 175, 250 feet contain recognisable Foraminifera, and one pebble, from 175 feet, is crowded with specimens recognised by von Zittel as "belonging to the Textularidæ, Rotalidæ, and Globigerinæ." Of these there are other specimens from a depth of 270 feet. Dr. von Zittel states: "I hold it as probable that these pebbles come from the Eocene of the Nile valley. Flinty layers and concretions are extremely common in the Egyptian Eocene (as, for example, in Central and Upper Egypt). The absence of sections of *Nummulites* and *Alveolina* is particularly noticeable."

At the request of Dr. von Zittel the sections containing Foraminifera were submitted to Professor T. Rupert Jones, F.R.S., who, with the aid of Mr. F. Chapman, has examined and reported upon them. The following notes on certain of the fossiliferous pebbles are based on the reports kindly furnished to me:—

From a depth of 160 feet a pebble was obtained containing both Foraminifera and, apparently, sponge-spicules. The species recognised were—

Globigerina bulloides d'Orb. (a form with a thick prickly test, probably a deep-sea variety).

G. sp., a depressed form.
Cristellaria or *Nummulites*

A flint with numerous and very well preserved examples of Foraminifera was obtained from a depth of 175 feet, and in several sections made from this pebble the following forms were detected:—

Textularia globulosa, Ehrb.
„ *sagittula*, Defrance.
Bolivina (?) dilatata, Reuss.
„ *punctata*, d'Orb.
Globigerina bulloides, d'Orb.
Discorbina globularis, d'Orb.
Rotalia ammoniformis, Lamk.
Anomalina, sp.
Spiroloculina, sp.

From the same depth of 175 feet a pebble of chert (apparently a silicified dolomitic limestone) yielded the following:—

Bolivina obsoleta, Ehrb.
Globigerina bulloides, d'Orb.

From a depth of 250 feet a flint pebble was obtained, which has all the appearance under the microscope of being a silicified ooze, crowded with specimens of *Globigerina bulloides* d'Orb. (a variety with a thick-walled test), and containing also the following species:—

Rotalia ammoniformis, Lamk.
Polymorphina compressa, d'Orb.
Pulvinulina, sp., &c.

From a depth of 270 feet several flint pebbles were obtained which contained organisms, but these appear to have been partially dissolved before silicification took place, and hence identification is difficult. They include *Globigerina*, *Discorbina*, &c.

The whole of these fossils are regarded by Professor Rupert Jones as proving that the fragments containing them were derived from the Eocene (Nummulitic) limestones of Egypt, thus fully confirming the conclusions of Dr. von Zittel.

At the depth of 121 feet a pebble of a somewhat different class of rock was obtained. It appears to be an indurated sandstone with detrital fragments of wood, Foraminifera of the following species:—

Lagena lævis, Mont.
„ *globosa*, Mont.
Globigerina, sp.
Discorbina, sp.

and, in addition, a Lithistid sponge-spicule, an ostracod valve (Cythere ?), fragments of spines of Echini, a Radiolarian (?), and

oolitic grains (silicified) were detected. This rock may have come from a Cretaceous deposit, and not from the Eocene like the others.

Of the general sources from which these pebbles were derived Dr. von Zittel writes as follows :—

"On the whole it appears to me conceivable that these gravels under the delta originated at a time when the Nile had already formed its present valley, but not to so great a depth as at present. The majority of the rolled rock-fragments would seem not to have been derived from points extremely distant from those in which they are at present found."

In considering the nature and sources of the pebbles found in the boring at Zagazig, it may be well to point out that the spot where the boring was carried out is directly opposite to the Great Wady (W. Tumilat), which opens on the delta from the east, and that much of the materials composing the gravels may have been brought down by this tributary rather than by the main stream of the Nile itself. Hence we may not have in this particular section so good an average sample of the contents of the Sub-delta formation as would be obtained at other localities.

There can scarcely be the smallest doubt that in this Sub-delta formation we have a series of deposits, which were formed under totally different conditions from those which prevail in North Eastern Africa at the present time. The land must have been at an elevation at least from 100 to 300 feet higher than at present, and the Lower Nile, instead of forming an alluvial flat, as at present, must have deposited coarse sands and gravels. It is upon the very uneven surface of this Sub-delta deposit that the alluvial mud and sands of the delta have been deposited, as the surface gradually subsided below the level of the Mediterranean.

The interesting problem of the geological age of this Sub-delta deposit remains to be solved, but it may be hoped that the explorations now being carried on by the Geological Survey of Egypt, under Captain H. G. Lyons, R.E., F.G.S., may furnish new and important evidence bearing on this important question.

It is to be regretted that the borings carried out by the Royal Society have not set at rest the doubts which have long existed as to the depth at which the solid rock-floor lies below the surface of the delta. But while this has not yet been accomplished, it is satisfactory to have been able to show that the supposed insignificant thickness of the alluvial deposits is altogether a mistake, while the existence of an underlying formation, laid down under conditions totally different to those which prevail at present, has been demonstrated.

Communications have lately passed between the English War Department, the Egyptian Public Works Department, and the Royal

Society, which lead us to hope that borings, to be shortly undertaken for economic purposes, may, either with or without aid from this Society, supply the means of reaching greater depths than that attained at Zagazig, and possibly of reaching the old floor of solid rocks on which the Sub-delta deposits rest.

"The Palæolithic Deposits at Hitchin and their Relation to the Glacial Epoch." By CLEMENT REID, F.L.S., F.G.S., of the Geological Survey of the United Kingdom. Communicated by Sir ARCHIBALD GEIKIE, F.R.S. Received February 15,—Read March 4, 1897.

Certain excavations and borings at Hoxne, undertaken in the year 1896 at the cost of the British Association and of the Royal Society, threw much light on the relation of Palæolithic man to the Glacial Epoch. It was thought advisable therefore to examine the similar deposits at Hitchin, to ascertain to what extent the conclusions already arrived at were supported by exploration at a fresh locality. It was desired also to see whether a new locality would aid us in restoring pages in the geological history missing in the Hoxne record. At the instance of Sir Archibald Geikie, a grant of £50 was made by the Council of the Royal Society towards the cost of the necessary excavations, borings, and incidental expenses, unavoidable if the inquiry was to be carried out satisfactorily. Of this sum, only about £30 has been expended, for, after reaching a certain stage with good results, it was discovered that any further advance meant a far greater expenditure of time and money than seemed justified. Work was therefore stopped as soon as the main point under dispute had been cleared up, and a sufficient series of fossil plants had been obtained to determine the climatic conditions that held while the ancient alluvial strata were being deposited.

It is perhaps scarcely necessary under the circumstances to do more than allude to the results of previous work. Palæolithic implements have long been known from Hitchin, and their position in and at the base of a stony brickearth was well ascertained. It was also known that this brickearth rested on loam and shell marl, with fresh-water mollusca and mammalian remains. All this had been made perfectly clear, principally by the researches of Prestwich, Sir John Evans, Mr. W. Ransom, and Mr. William Hill. The most important of the doubtful points were the relations of these ancient alluvia to the widespread sheet of chalky boulder clay, and to the valleys of the existing streams.

In the prosecution of these supplementary researches I have been greatly aided by the local assistance freely rendered by Mr. William